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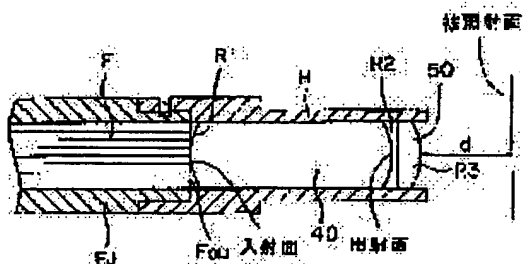
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## (54) LIGHTING DEVICE

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To provide a lighting device capable of getting a lighting part close to a work and lighting the work at a high lighting illuminance without enlarging the diameter of the lighting part, and of efficient lighting without center drop of light on a lighted surface even if the lighting part and the work are far apart.

**SOLUTION:** This lighting device enters light from a discharge lamp into an incident end of a light guide F and concentrates light emitted from an emission end of the light guide F on a lighted surface by a projection optics system, and lights a work arranged on the lighted surface. The projection optics system is comprised of a rod lens 40 having spherical surfaces of the same radius of curvature on both ends, a plano-convex lens 50 or a both-side convex lens. Also, this projection optics system is constructed with the rod lens having spherical surface on both ends and a radius of curvature of the emission end spherical surface of the rod lens is kept smaller than the radius of curvature of the incident end spherical surface.



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**CLAIMS**

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**[Claim(s)]**

**[Claim 1]** Condense the light emitted from the discharge lamp by the mirror, and incidence of the light which condensed is carried out to the incidence edge of the light guide arranged on the optical axis of a mirror. In the light irradiation device which irradiates the irradiated object which condensed the above-mentioned light which carries out outgoing radiation from the outgoing radiation edge of a light guide to the irradiated plane according to projection optics, and has been arranged at the irradiated plane said projection optics The light irradiation device characterized by having the spherical surface with the same radius of curvature to both ends, and consisting of a rod lens arranged by an incidence edge approaching the outgoing radiation edge of this light guide, and the planoconvex or the biconvex lens arranged by approaching the outgoing radiation edge of this rod lens.

**[Claim 2]** Condense the light emitted from the discharge lamp by the mirror, and incidence of the light which condensed is carried out to the incidence edge of the light guide arranged on the optical axis of a mirror. In the light irradiation device which irradiates the irradiated object which condensed the above-mentioned light which carries out outgoing radiation from the outgoing radiation edge of a light guide to the irradiated plane according to projection optics, and has been arranged at the irradiated plane said projection optics The light irradiation device characterized by the radius of curvature of the spherical surface of the outgoing radiation edge of this rod lens being smaller than the radius of curvature of the spherical surface of an incidence edge by the both ends where the incidence edge has been arranged by approaching the outgoing radiation edge of this light guide consisting of a rod lens of the spherical surface.

**[Claim 3]** The light irradiation device according to claim 1 or 2 characterized by irradiating said light at said irradiated object with which ultraviolet curing adhesives were applied.

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the light irradiation device suitable for irradiating the light which includes ultraviolet rays to the field of the still narrower range about the light irradiation device which irradiates the irradiated object (work piece) which drew the light emitted from a discharge lamp by the light guide, and has been arranged at the irradiated plane, and performs optical processing, and performing ultraviolet treatment.

[0002]

[Description of the Prior Art] Irradiate the adhesives applied to the work piece, a coating, ink, a resist, etc., and they are made to harden the light by which outgoing radiation is carried out from a light irradiation device, or making it dry is performed. Moreover, conversely, melting of these is carried out or various processings of making it soften etc. are performed. And it is necessary to irradiate light in a minute region, and in adhesion of the pickup lens for optical disks by ultraviolet curing mold adhesives, and adhesion to the substrate of electronic parts etc., it leads by the light guide constituted [ optical fibers / many ] by bundling in the light of a discharge lamp, and it irradiates a minute region.

[0003] Drawing 1 shows an example of the internal configuration of the light irradiation device for irradiating a minute region. It is fixed to an attachment component 30, and the mirror 20 is being fixed to the attachment component 30 where a discharge lamp 10 is also inserted in the through tube 21 of a mirror 20. A discharge lamp 10 is a discharge lamp of short arc molds, such as a xenon lamp and an extra-high pressure mercury lamp, and opposite arrangement of cathode 11 and the anode plate 12 is carried out within luminescence. A cross-section configuration is an ellipse form and, as for a mirror 20, the luminescent spot of the light-emitting part between the cathode 11 of a discharge lamp 10 and an anode plate 12 is located in the 1st focus of a mirror 20. Usually, the luminescent spot of a light-emitting part is near a cathode tip. A light guide F is arranged on the optical axis L of a mirror 20, and the incidence edge Fin of a light guide F is located in the 2nd focus of a mirror 20. Moreover, Shutter St is arranged between the incidence edge Fin of a light guide F, and the discharge lamp 10, and if Shutter St is opened, incidence of the light condensed by the mirror 20 will be carried out to the incidence edge Fin of a light guide F. And the light which carried out outgoing radiation from the outgoing radiation edge Fou of a light guide F is irradiated by lens components, a substrate, etc. with which the work piece which performs optical exposure processing arranged to the optical exposure field in an irradiated plane, for example, ultraviolet curing mold adhesives, was applied.

[0004] In this light irradiation device, since the through tube 21 is formed in the central part of a mirror 20 as described above, only the light shown with the dotted-line slash in drawing 1 carries out incidence of the light which the reflected light does not exist in this part, but is reflected by the mirror 20 to the incidence edge Fin of a light guide F. That is, a big light of whenever [ incident angle ] carries out many incidence to the incidence edge Fin, and incidence of the small light near 0 degree which is whenever [ incident angle ] is hardly carried out to it.

[0005] The light which carried out incidence to the incidence edge Fin of a light guide F repeats reflection, where an include angle is held as a property of an optical fiber, and it transmits the

inside of a light guide F, and it carries out outgoing radiation from the outgoing radiation edge Fou at the same include angle as an incident angle. Since a big light of whenever [ incident angle ] carries out many incidence to a light guide F as described above, light with the big outgoing radiation include angle shown with the dotted-line slash in drawing 1 carries out many outgoing radiation of the light which carries out outgoing radiation from the outgoing radiation edge Fou. Here, if the distance d of the outgoing radiation edge Fou of a light guide F and the irradiated plane by which a work piece is arranged is short, since the light near 0 degree with a small outgoing radiation include angle has the magnitude of [ to some extent ]  $\phi 5\text{mm}$  or  $\phi 3.5\text{mm}$  in the diameter of convergence of the optical fiber of a light guide F at least, the central illuminance of the illuminance distribution of an irradiated plane will be high, and it will become as low Yamagata as a periphery.

[0006] However, if the distance d of the outgoing radiation edge Fou of a light guide F and an irradiated plane becomes large, compared with a periphery, a center section will become low, and the phenomenon called "Extract inside" will produce the illuminance of the exposure field in an irradiated plane. Drawing 2 shows the relation of "extract inside" with the distance d of the outgoing radiation edge Fou of a light guide F, and an irradiated plane, when the diameter of convergence of an optical fiber is  $\phi 3.5\text{mm}$ , but if distance d is set to 20mm or more, the phenomenon "extracted inside" will become remarkable. And distance d of the outgoing radiation edge Fou of a light guide F and the irradiated plane by which a work piece is arranged is set to 20mm or more in many cases from the relation of carrying in of the magnitude of a work piece, a configuration, and a work piece, and path clearance with a taking-out device etc.

[0007] In order to shorten the optical processing time, it is necessary to process with a high illuminance. However, if small work pieces, such as a pickup lens for optical disks, are arranged in the center of an exposure field when the distance of the outgoing radiation edge Fou and the irradiated plane by which a work piece is arranged is long, the illuminance of the light irradiated by the work piece for the phenomenon "extracted inside" will become low, and the processing time will become long. For this reason, a work piece is shifted from the center of an exposure field, and the illuminance is arranging and irradiating the periphery of a high exposure field. However, if the distance d of the time of carrying out optical processing of the work piece of a different class, and the outgoing radiation edge Fou of a light guide F and the irradiated plane by which a work piece is arranged is changed, it is necessary to measure the illumination distribution of an irradiated plane each time, to ask for the location where an illuminance becomes the highest, and to set up suitably so that a work piece may come to the location. moreover — since the field where an illuminance is high is the periphery of an exposure field and the range is narrow — precision — good — a work-piece location — doubling — being crowded — stage picking — time and effort and time amount were required for changing.

[0008]

[Problem(s) to be Solved by the Invention] In order to cancel this phenomenon "extracted inside", it is possible to condense the light which carries out outgoing radiation from the outgoing radiation edge of a light guide to an irradiated plane in projection optics, and to irradiate the work piece arranged at the irradiated plane. In this case, since the illumination distribution of the outgoing radiation edge of a light guide is projected on an irradiated plane in projection optics, while being able to irradiate light efficiently to the field which needs an exposure in an irradiated plane, the phenomenon of illumination distribution "extracted inside" is cancelable.

[0009] Using the lens unit which combined two or more lenses as the above-mentioned projection optics for JP,64-75067,A is indicated. Drawing 3 shows an example of the lens unit LU which consists of the 1st lens L1 and the 2nd lens L2, the lens unit LU is attached in a light guide outgoing radiation edge, and the optical exposure section is constituted. In drawing 3, the light which carried out outgoing radiation from the outgoing radiation edge Fou of a light guide F has fixed breadth according to the numerical aperture NA of the optical fiber which forms a light guide F. for example, the case of the optical fiber made from quartz glass — numerical-aperture  $\text{NA} =$  — it is about 0.22 and the angle of divergence in the air is equivalent to about 12.7 degrees.

[0010] Here, if the lenses L1 and L2 of the lens unit LU are brought close to the outgoing

radiation edge Fou of a light guide F, the scale factor projected on an irradiated plane by the lens unit LU will become large. That is, since the projected area in an irradiated plane becomes large, the illuminance of the whole exposure field becomes low. Therefore, in order to irradiate a narrow field with a high illuminance, only predetermined distance needs to separate the lenses L1 and L2 of the lens unit LU from the outgoing radiation edge Fou of a light guide F. And in order to use effectively the light which carried out outgoing radiation from the outgoing radiation edge Fou of a light guide F, most light which spread in about 12.7-degree above mentioned angle of divergence must be condensed with a lens, but for that purpose, as shown in drawing 3, it is necessary to enlarge the diameter of a lens of the lens unit LU. For this reason, the diameter of a lens unit containing the holder H holding a lens becomes quite larger than the path of a light guide F, and the configuration of the optical outgoing radiation section is enlarged. In addition, since it is necessary to lengthen distance from the outgoing radiation edge Fou of a light guide F to a lens also when lengthening distance of a lens and an irradiated plane, as described above, a lens system becomes large and the configuration of the optical outgoing radiation section is enlarged.

[0011] Although the fixture for fixing a work piece may have enclosed the surroundings of it in actual optical exposure processing or it may be located in the inside where the part which irradiates light was surrounded by other components mounted in the substrate Anyway, if the configuration of the optical outgoing radiation section is large-sized, the optical outgoing radiation section cannot be made to be fully able to approach the part which irradiates the light of a work piece, and cannot be irradiated, but there is fault which cannot obtain desired irradiance.

[0012] Then, this invention aims at offering the light irradiation device [ it is possible for the path of the optical outgoing radiation section not to be enlarged, to make the optical outgoing radiation section approach a work piece, and to carry out an optical exposure with high irradiance, and ] which there is "no extract inside" even if the optical outgoing radiation section and a work piece are separated, and can carry out an optical exposure efficiently. [ of the light irradiated by the irradiated plane ]

[0013]

[Means for Solving the Problem] In order to attain this purpose, invention of claim 1 Condense the light emitted from the discharge lamp by the mirror, and incidence of the light which condensed is carried out to the incidence edge of the light guide arranged on the optical axis of a mirror. In the light irradiation device which irradiates the work piece which condensed the light which carries out outgoing radiation from the outgoing radiation edge of a light guide to the irradiated plane according to projection optics, and has been arranged at the irradiated plane It has the spherical surface with the same radius of curvature to both ends, and projection optics consists of a rod lens by which the incidence edge has been arranged by approaching the outgoing radiation edge of a light guide, and the planoconvex or the biconvex lens arranged by approaching the outgoing radiation edge of this rod lens. Moreover, the both ends where the incidence edge has been arranged by approaching the outgoing radiation edge of a light guide constitute this projection optics from a rod lens of the spherical surface, and invention of claim 2 makes the radius of curvature of the spherical surface of the outgoing radiation edge of a rod lens smaller than the radius of curvature of the spherical surface of an incidence edge. Furthermore, invention of claim 3 uses the light irradiation device equipped with the projection optics constituted as mentioned above, in order to harden ultraviolet curing mold adhesives.

[0014]

[Embodiment of the Invention] Below, based on a drawing, the gestalt of operation of this invention is explained concretely. Drawing 4 is the sectional view of the example of the optical outgoing radiation section of invention of claim 1. That is, the light source part of the light irradiation device of this invention is as being shown in drawing 1, and has structure which the point of the light guide F of drawing 1 R> 1 shows to drawing 4. In drawing 4, it arranges and a light guide F bundles many optical fibers which consist of quartz glass so that the location in the incidence edge Fin of each optical fiber and the location in the outgoing radiation edge Fou may become random. The side face of the outgoing radiation edge Fou of this light guide F is covered

by the joint FJ which is tubed hardware, and the tubed electrode holder H is joined to Joint FJ. And in the electrode holder H, the rod lens 40 and plano-convex lens 50 made from quartz glass which work as projection optics are held. Here, it is somewhat large in whether the outer diameter of a rod lens 40 and a plano-convex lens 50 is almost equal to the diameter of convergence of an optical fiber. The example of the diameter of convergence of an optical fiber is  $\phi 3.5\text{mm}$ , and the outer diameter of Joint FJ is  $\phi 9\text{mm}$ . The outer diameter of a rod lens 40 and a plano-convex lens 50 is [ whether it is the same as  $\phi 3.5\text{mm}$ , and ] a little large extent. therefore — without it makes the outer diameter of an electrode holder H larger than the outer diameter of Joint FJ — projection optics — \*\*\*\* — since things are made, the outer diameter of the optical outgoing radiation section is not expanded.

[0015] The both ends of a rod lens 40 are the spherical surfaces, and another [ the plane of incidence to which one edge carries out incidence of the light from a light guide F, and ] edge is an outgoing radiation side which carries out outgoing radiation of the light which carried out incidence. The plane of incidence of a rod lens 40 is approached and prepared in the outgoing radiation edge Fou of a light guide F. That is, the plane of incidence of a rod lens 40 contacts the outgoing radiation edge Fou of a light guide F, or is held at intervals of [ short ] less than 1mm. Radius of curvature R1 of the plane of incidence of a rod lens 40 Radius of curvature R2 of an outgoing radiation side It is equal. moreover, the radius of curvature of a plano-convex lens 50 prepared in the outgoing radiation side side of a rod lens 40 — R3 it is — this radius of curvature R3 and the radius of curvature R1 (= R2) of a rod lens 40, and the optical-axis lay length of a rod lens 40 are designed according to the distance d to the irradiated plane which makes the light which carried out outgoing radiation of the plano-convex lens 50 condense. In addition, a plano-convex lens 50 may be a biconvex lens.

[0016] Although drawing 5 shows the example of the optical outgoing radiation section of invention of claim 2, in the electrode holder H, only the rod lens 40 with it is held. [ an outer diameter almost equal to the diameter of convergence of an optical fiber or and ] [ somewhat larger ] The both ends of a rod lens 40 are the radius of curvatures R2 of an outgoing radiation side, although it is the spherical surface like the case of the 1st example of the above. Radius of curvature R1 of plane of incidence By making it small, it can make it unnecessary to prepare a convex lens in the outgoing radiation side of a rod lens 40. And radius of curvature R1 And R2 The optical-axis lay length of a rod lens 40 is designed according to the distance d to the irradiated plane which makes the light which carried out outgoing radiation of the rod lens 40 condense.

[0017] Although a deer is carried out, incidence of the light condensed by the mirror 20 will be carried out to the incidence edge Fin of a light guide F and outgoing radiation will be carried out from the outgoing radiation edge Fou of a light guide F if the discharge lamp 10 shown in drawing 1 is turned on and Shutter St is opened As shown in drawing 6 in invention of claim 1, the light of the outgoing radiation edge Fou of a light guide F which carried out outgoing radiation from the optical fiber of a center section mostly If the maximum outgoing radiation include angle is made into 12.7 degrees (equivalent to about 0.22 of NA of a fiber), it will be refracted by the plane of incidence of a rod lens 40, and the outgoing radiation side of a rod lens 40 will be arrived at with breadth at the include angle of about 8.6 degrees. And outgoing radiation is carried out as a light almost parallel to an optical axis from the outgoing radiation side of a rod lens 40. On the other hand, since the plane of incidence of a rod lens 40 is a spherical-surface configuration, the light which carried out outgoing radiation from the optical fiber of the periphery of the outgoing radiation edge Fou of a light guide F is refracted in the direction of an optical axis of a light guide F, carries out incidence to a rod lens 40, and reaches the outgoing radiation side of a rod lens 40 with breadth at the include angle of about 8.6 degrees after that. And it laps with the light which carried out outgoing radiation from the center section of the light guide F in respect of the outgoing radiation of a rod lens 40, and outgoing radiation is carried out from the outgoing radiation side of a rod lens 40 at the include angle near 12.7 degrees to an optical axis. in addition — a rod lens — 40 — inside — an angle of divergence — whenever — theta — ' (about 8.6 degrees) — a rod lens — 40 — the quality of the material — it is — quartz glass — a refractive index — n — ' (= 1.47) — air — a refractive index — n (= 1) — air — inside — an

angle of divergence — whenever —  $\theta$  (12.7 degrees) — from — a Snell's law ( $n \sin \theta = n' \sin \theta'$ ) — being based — it can ask .

[0018] In order to use light most efficiently, as shown in drawing 6 , as for the light which carried out incidence to the rod lens 40, it is desirable to spread into the outgoing radiation flat-tapped cup of a rod lens 40 in the peripheral face of a rod lens 40. Then, since the quality of the material is quartz glass, and whenever [ angle-of-divergence ] is about 8.6 degrees when a path is  $\phi 3.5\text{mm}$ , the die length of a rod lens 40 is better than about 12mm or 12mm to make it a short jar a little.

[0019] The light which carried out incidence of the light which carried out outgoing radiation from the outgoing radiation side of a rod lens 40 to the plano-convex lens 50, and carried out outgoing radiation from the plano-convex lens 50 is the radius of curvature R3 of a plano-convex lens 50. It is based, and it is refracted and condenses to the optical exposure side of the set-up location. Here, the distance d from a plano-convex lens 50 to an irradiated plane is equivalent to the focal distance of a plano-convex lens 50. That is, a rod lens 40 and a plano-convex lens 50 commit the projection lens which projects the illumination distribution of the outgoing radiation edge Fou of a light guide F on an irradiated plane. Moreover, the illuminance distribution of the outgoing radiation edge Fou of a light guide F is equalized by the effectiveness of the random arrangement of an optical fiber. Therefore, by work of a rod lens 40, even if it lengthens distance d from the outgoing radiation section to an irradiated plane, "extract inside" does not arise in the illumination distribution of the exposure field in an irradiated plane.

[0020] Drawing 8 shows the irradiance distribution curve of the above-mentioned example which prepared the projection optics which consists of a rod lens 40 and a plano-convex lens 50 in the outgoing radiation edge Fou of a light guide F, and the conventional example shown in drawing 1 which does not prepare projection optics in the outgoing radiation edge Fou of a light guide F. Although the irradiance distribution curve in case the distance d from a plano-convex lens 50 thru/or the outgoing radiation edge Fou of a light guide F to an irradiated plane is 15mm and 20mm was searched for, the rod lens 40 and the plano-convex lens 50 were designed as the aforementioned distance of  $d = 15\text{mm}$ . Moreover, the diameter of convergence of an optical fiber is  $\phi 3.5\text{mm}$ .

[0021] The phenomenon "extract inside" in any [  $d = 15\text{mm}$  and  $d = 20\text{mm}$  ] case was not accepted for this example so that drawing 8 might show. And since light was condensed by the irradiated plane which is  $d = 15\text{mm}$ , the illuminance of this example of an exposure field center section was much larger than the conventional example, and the sharp distribution curve was acquired. The illuminance of an exposure field center section being not only lower than this example but the phenomenon on the other hand, "be extracted inside" in the conventional example in the case of  $d = 20\text{mm}$  was seen.

[0022] Although drawing 7 shows one example of the optical-path Fig. of invention of claim 2 which does not use a plano-convex lens 50, it is the same as drawing 6 which shows the optical-path Fig. of invention of claim 1 until the light which carried out incidence to the rod lens 40 arrives at an outgoing radiation side. However, radius of curvature R2 of the outgoing radiation side of a rod lens 40 Radius of curvature R1 of plane of incidence Since it is small, light is refracted more greatly than the time of incidence, and outgoing radiation of it is carried out from a rod lens 40, and it condenses to the optical exposure side of the set-up location. That is, since a rod lens 40 commits the projection lens which projects the illumination distribution of the outgoing radiation edge Fou of a light guide F on an irradiated plane, it is and "extract inside" does not produce the same effectiveness as having used the plano-convex lens 50 in the illumination distribution of the exposure field in an irradiated plane. And since a plano-convex lens 50 is not used, components mark can be lessened, and since loss of the light by reflection or absorption decreases, an illuminance becomes high.

[0023]

[Effect of the Invention] As explained above, since this invention condenses the light which carries out outgoing radiation from a light guide to an irradiated plane according to the projection optics which consists of a rod lens or a rod lens, planoconvex, or a biconvex lens, also when the distance to an irradiated plane is large, the phenomenon "be extracted inside" to illumination



distribution does not occur, but it can make the irradiance of an exposure field center section high. Moreover, it is \*\*\*\*\* to make the path of a rod lens and planoconvex, or a biconvex lens almost equivalent to the path of a light guide by replacing this air space with a rod lens with a large refractive index, although there were many rates that the air space between lenses occupies between a light guide and a lens and the diameter of a part lens was large conventionally. Therefore, in spite of having prepared projection optics in the outgoing radiation edge of a light guide, the path of the optical outgoing radiation section is not expanded. For this reason, also when the path clearance of the work piece which is an irradiated object, its carrying-in device, etc. is small, it becomes possible to make the optical outgoing radiation section approach a work piece. Moreover, even if the distance from the outgoing radiation section to a work piece becomes large, light without "extract inside" can be irradiated. Therefore, even if it can adjust exposure conditions easily and the quality of the material and the class of work piece change irrespective of the merits and demerits of the distance from an outgoing radiation edge to an irradiated plane, it can respond free to the exposure condition.

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**TECHNICAL FIELD**

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[Field of the Invention] This invention relates to the light irradiation device suitable for irradiating the light which includes ultraviolet rays to the field of the still narrower range about the light irradiation device which irradiates the irradiated object (work piece) which drew the light emitted from a discharge lamp by the light guide, and has been arranged at the irradiated plane, and performs optical processing, and performing ultraviolet treatment.

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**PRIOR ART**

[Description of the Prior Art] Irradiate the adhesives applied to the work piece, a coating, ink, a resist, etc., and they are made to harden the light by which outgoing radiation is carried out from a light irradiation device, or making it dry is performed. Moreover, conversely, melting of these is carried out or various processings of making it soften etc. are performed. And it is necessary to irradiate light in a minute region, and in adhesion of the pickup lens for optical disks by ultraviolet curing mold adhesives, and adhesion to the substrate of electronic parts etc., it leads by the light guide constituted [ optical fibers / many ] by bundling in the light of a discharge lamp, and it irradiates a minute region.

[0003] Drawing 1 shows an example of the internal configuration of the light irradiation device for irradiating a minute region. It is fixed to an attachment component 30, and the mirror 20 is being fixed to the attachment component 30 where a discharge lamp 10 is also inserted in the through tube 21 of a mirror 20. A discharge lamp 10 is a discharge lamp of short arc molds, such as a xenon lamp and an extra-high pressure mercury lamp, and opposite arrangement of cathode 11 and the anode plate 12 is carried out within luminescence. A cross-section configuration is an ellipse form and, as for a mirror 20, the luminescent spot of the light-emitting part between the cathode 11 of a discharge lamp 10 and an anode plate 12 is located in the 1st focus of a mirror 20. Usually, the luminescent spot of a light-emitting part is near a cathode tip. A light guide F is arranged on the optical axis L of a mirror 20, and the incidence edge Fin of a light guide F is located in the 2nd focus of a mirror 20. Moreover, Shutter St is arranged between the incidence edge Fin of a light guide F, and the discharge lamp 10, and if Shutter St is opened, incidence of the light condensed by the mirror 20 will be carried out to the incidence edge Fin of a light guide F. And the light which carried out outgoing radiation from the outgoing radiation edge Fou of a light guide F is irradiated by lens components, a substrate, etc. with which the work piece which performs optical exposure processing arranged to the optical exposure field in an irradiated plane, for example, ultraviolet curing mold adhesives, was applied.

[0004] In this light irradiation device, since the through tube 21 is formed in the central part of a mirror 20 as described above, only the light shown with the dotted-line slash in drawing 1 carries out incidence of the light which the reflected light does not exist in this part, but is reflected by the mirror 20 to the incidence edge Fin of a light guide F. That is, a big light of whenever [ incident angle ] carries out many incidence to the incidence edge Fin, and incidence of the small light near 0 degree which is whenever [ incident angle ] is hardly carried out to it.

[0005] The light which carried out incidence to the incidence edge Fin of a light guide F repeats reflection, where an include angle is held as a property of an optical fiber, and it transmits the inside of a light guide F, and it carries out outgoing radiation from the outgoing radiation edge Fou at the same include angle as an incident angle. Since a big light of whenever [ incident angle ] carries out many incidence to a light guide F as described above, light with the big outgoing radiation include angle shown with the dotted-line slash in drawing 1 carries out many outgoing radiation of the light which carries out outgoing radiation from the outgoing radiation edge Fou. Here, if the distance d of the outgoing radiation edge Fou of a light guide F and the irradiated plane by which a work piece is arranged is short, since the light near 0 degree with a small outgoing radiation include angle has the magnitude of [ to some extent ]  $\phi 5\text{mm}$  or

phi3.5mm in the diameter of convergence of the optical fiber of a light guide F at least, the central illuminance of the illuminance distribution of an irradiated plane will be high, and it will become as low Yamagata as a periphery.

[0006] However, if the distance d of the outgoing radiation edge Fou of a light guide F and an irradiated plane becomes large, compared with a periphery, a center section will become low, and the phenomenon called "Extract inside" will produce the illuminance of the exposure field in an irradiated plane. Drawing 2 shows the relation of "extract inside" with the distance d of the outgoing radiation edge Fou of a light guide F, and an irradiated plane, when the diameter of convergence of an optical fiber is phi3.5mm, but if distance d is set to 20mm or more, the phenomenon "extracted inside" will become remarkable. And distance d of the outgoing radiation edge Fou of a light guide F and the irradiated plane by which a work piece is arranged is set to 20mm or more in many cases from the relation of carrying in of the magnitude of a work piece, a configuration, and a work piece, and path clearance with a taking-out device etc.

[0007] In order to shorten the optical processing time, it is necessary to process with a high illuminance. However, if small work pieces, such as a pickup lens for optical disks, are arranged in the center of an exposure field when the distance of the outgoing radiation edge Fou and the irradiated plane by which a work piece is arranged is long, the illuminance of the light irradiated by the work piece for the phenomenon "extracted inside" will become low, and the processing time will become long. For this reason, a work piece is shifted from the center of an exposure field, and the illuminance is arranging and irradiating the periphery of a high exposure field.

However, if the distance d of the time of carrying out optical processing of the work piece of a different class, and the outgoing radiation edge Fou of a light guide F and the irradiated plane by which a work piece is arranged is changed, it is necessary to measure the illumination distribution of an irradiated plane each time, to ask for the location where an illuminance becomes the highest, and to set up suitably so that a work piece may come to the location. moreover — since the field where an illuminance is high is the periphery of an exposure field and the range is narrow — precision — good — a work-piece location — doubling — being crowded — stage picking — time and effort and time amount were required for changing.

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**EFFECT OF THE INVENTION**

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[Effect of the Invention] As explained above, since this invention condenses the light which carries out outgoing radiation from a light guide to an irradiated plane according to the projection optics which consists of a rod lens or a rod lens, planoconvex, or a biconvex lens, also when the distance to an irradiated plane is large, the phenomenon "be extracted inside" to illumination distribution does not occur, but it can make the irradiance of an exposure field center section high. Moreover, it is \*\*\*\*\* to make the path of a rod lens and planoconvex, or a biconvex lens almost equivalent to the path of a light guide by replacing this air space with a rod lens with a large refractive index, although there were many cases that the air space between lenses occupies between a light guide and a lens and the diameter of a part lens was large conventionally. Therefore, in spite of having prepared projection optics in the outgoing radiation edge of a light guide, the path of the optical outgoing radiation section is not expanded. For this reason, also when the path clearance of the work piece which is an irradiated object, its carrying-in device, etc. is small, it becomes possible to make the optical outgoing radiation section approach a work piece. Moreover, even if the distance from the outgoing radiation section to a work piece becomes large, light without "extract inside" can be irradiated. Therefore, even if it can adjust exposure conditions easily and the quality of the material and the class of work piece change irrespective of the merits and demerits of the distance from an outgoing radiation edge to an irradiated plane, it can respond free to the exposure condition.

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[Translation done.]

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## TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention] In order to cancel this phenomenon "extracted inside", it is possible to condense the light which carries out outgoing radiation from the outgoing radiation edge of a light guide to an irradiated plane in projection optics, and to irradiate the work piece arranged at the irradiated plane. In this case, since the illumination distribution of the outgoing radiation edge of a light guide is projected on an irradiated plane in projection optics, while being able to irradiate light efficiently to the field which needs an exposure in an irradiated plane, the phenomenon of illumination distribution "extracted inside" is cancelable.

[0009] Using the lens unit which combined two or more lenses as the above-mentioned projection optics for JP,64-75067,A is indicated. Drawing 3 shows an example of the lens unit LU which consists of the 1st lens L1 and the 2nd lens L2, the lens unit LU is attached in a light guide outgoing radiation edge, and the optical exposure section is constituted. In drawing 3, the light which carried out outgoing radiation from the outgoing radiation edge Fou of a light guide F has fixed breadth according to the numerical aperture NA of the optical fiber which forms a light guide F. for example, the case of the optical fiber made from quartz glass — numerical-aperture NA= — it is about 0.22 and the angle of divergence in the air is equivalent to about 12.7 degrees.

[0010] Here, if the lenses L1 and L2 of the lens unit LU are brought close to the outgoing radiation edge Fou of a light guide F, the scale factor projected on an irradiated plane by the lens unit LU will become large. That is, since the projected area in an irradiated plane becomes large, the illuminance of the whole exposure field becomes low. Therefore, in order to irradiate a narrow field with a high illuminance, only predetermined distance needs to separate the lenses L1 and L2 of the lens unit LU from the outgoing radiation edge Fou of a light guide F. And in order to use effectively the light which carried out outgoing radiation from the outgoing radiation edge Fou of a light guide F, most light which spread in about 12.7-degree above mentioned angle of divergence must be condensed with a lens, but for that purpose, as shown in drawing 3, it is necessary to enlarge the diameter of a lens of the lens unit LU. For this reason, the diameter of a lens unit containing the holder H holding a lens becomes quite larger than the path of a light guide F, and the configuration of the optical outgoing radiation section is enlarged. In addition, since it is necessary to lengthen distance from the outgoing radiation edge Fou of a light guide F to a lens also when lengthening distance of a lens and an irradiated plane, as described above, a lens system becomes large and the configuration of the optical outgoing radiation section is enlarged.

[0011] Although the fixture for fixing a work piece may have enclosed the surroundings of it in actual optical exposure processing or it may be located in the inside where the part which irradiates light was surrounded by other components mounted in the substrate Anyway, if the configuration of the optical outgoing radiation section is large-sized, the optical outgoing radiation section cannot be made to be fully able to approach the part which irradiates the light of a work piece, and cannot be irradiated, but there is fault which cannot obtain desired irradiance.

[0012] Then, this invention aims at offering the light irradiation device [ it is possible for the path of the optical outgoing radiation section not to be enlarged, to make the optical outgoing

radiation section approach a work piece, and to carry out an optical exposure with high irradiance, and ] which there is "no extract inside" even if the optical outgoing radiation section and a work piece are separated, and can carry out an optical exposure efficiently. [ of the light irradiated by the irradiated plane ]

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[Translation done.]

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**MEANS**

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[Means for Solving the Problem] In order to attain this purpose, invention of claim 1 Condense the light emitted from the discharge lamp by the mirror, and incidence of the light which condensed is carried out to the incidence edge of the light guide arranged on the optical axis of a mirror. In the light irradiation device which irradiates the work piece which condensed the light which carries out outgoing radiation from the outgoing radiation edge of a light guide to the irradiated plane according to projection optics, and has been arranged at the irradiated plane It has the spherical surface with the same radius of curvature to both ends, and projection optics consists of a rod lens by which the incidence edge has been arranged by approaching the outgoing radiation edge of a light guide, and the planoconvex or the biconvex lens arranged by approaching the outgoing radiation edge of this rod lens. Moreover, the both ends where the incidence edge has been arranged by approaching the outgoing radiation edge of a light guide constitute this projection optics from a rod lens of the spherical surface, and invention of claim 2 makes the radius of curvature of the spherical surface of the outgoing radiation edge of a rod lens smaller than the radius of curvature of the spherical surface of an incidence edge. Furthermore, invention of claim 3 uses the light irradiation device equipped with the projection optics constituted as mentioned above, in order to harden ultraviolet curing mold adhesives.

[0014]

[Embodiment of the Invention] Below, based on a drawing, the gestalt of operation of this invention is explained concretely. Drawing 4 is the sectional view of the example of the optical outgoing radiation section of invention of claim 1. That is, the light source part of the light irradiation device of this invention is as being shown in drawing 1, and has structure which the point of the light guide F of drawing 1 R> 1 shows to drawing 4. In drawing 4, it arranges and a light guide F bundles many optical fibers which consist of quartz glass so that the location in the incidence edge Fin of each optical fiber and the location in the outgoing radiation edge Fou may become random. The side face of the outgoing radiation edge Fou of this light guide F is covered by the joint FJ which is tubed hardware, and the tubed electrode holder H is joined to Joint FJ. And in the electrode holder H, the rod lens 40 and plano-convex lens 50 made from quartz glass which work as projection optics are held. Here, it is somewhat large in whether the outer diameter of a rod lens 40 and a plano-convex lens 50 is almost equal to the diameter of convergence of an optical fiber. The example of the diameter of convergence of an optical fiber is  $\phi 3.5\text{mm}$ , and the outer diameter of Joint FJ is  $\phi 9\text{mm}$ . The outer diameter of a rod lens 40 and a plano-convex lens 50 is [ whether it is the same as  $\phi 3.5\text{mm}$ , and ] a little large extent. therefore — without it makes the outer diameter of an electrode holder H larger than the outer diameter of Joint FJ — projection optics — \*\*\*\* — since things are made, the outer diameter of the optical outgoing radiation section is not expanded.

[0015] The both ends of a rod lens 40 are the spherical surfaces, and another [ the plane of incidence to which one edge carries out incidence of the light from a light guide F, and ] edge is an outgoing radiation side which carries out outgoing radiation of the light which carried out incidence. The plane of incidence of a rod lens 40 is approached and prepared in the outgoing radiation edge Fou of a light guide F. That is, the plane of incidence of a rod lens 40 contacts the outgoing radiation edge Fou of a light guide F, or is held at intervals of [ short ] less than 1mm.



Radius of curvature R1 of the plane of incidence of a rod lens 40 Radius of curvature R2 of an outgoing radiation side It is equal. moreover, the radius of curvature of a plano-convex lens 50 prepared in the outgoing radiation side side of a rod lens 40 — R3 it is — this radius of curvature R3 and the radius of curvature R1 (= R2) of a rod lens 40, and the optical-axis lay length of a rod lens 40 are designed according to the distance d to the irradiated plane which makes the light which carried out outgoing radiation of the plano-convex lens 50 condense. In addition, a plano-convex lens 50 may be a biconvex lens.

[0016] Although drawing 5 shows the example of the optical outgoing radiation section of invention of claim 2, in the electrode holder H, only the rod lens 40 with it is held. [ an outer diameter almost equal to the diameter of convergence of an optical fiber or and ] [ somewhat larger ] The both ends of a rod lens 40 are the radius of curvatures R2 of an outgoing radiation side, although it is the spherical surface like the case of the 1st example of the above. Radius of curvature R1 of plane of incidence By making it small, it can make it unnecessary to prepare a convex lens in the outgoing radiation side of a rod lens 40. And radius of curvature R1 And R2 The optical-axis lay length of a rod lens 40 is designed according to the distance d to the irradiated plane which makes the light which carried out outgoing radiation of the rod lens 40 condense.

[0017] Although a deer is carried out, incidence of the light condensed by the mirror 20 will be carried out to the incidence edge Fin of a light guide F and outgoing radiation will be carried out from the outgoing radiation edge Fou of a light guide F if the discharge lamp 10 shown in drawing 1 is turned on and Shutter St is opened As shown in drawing 6 in invention of claim 1, the light of the outgoing radiation edge Fou of a light guide F which carried out outgoing radiation from the optical fiber of a center section mostly If the maximum outgoing radiation include angle is made into 12.7 degrees (equivalent to about 0.22 of NA of a fiber), it will be refracted by the plane of incidence of a rod lens 40, and the outgoing radiation side of a rod lens 40 will be arrived at with breadth at the include angle of about 8.6 degrees. And outgoing radiation is carried out as a light almost parallel to an optical axis from the outgoing radiation side of a rod lens 40. On the other hand, since the plane of incidence of a rod lens 40 is a spherical-surface configuration, the light which carried out outgoing radiation from the optical fiber of the periphery of the outgoing radiation edge Fou of a light guide F is refracted in the direction of an optical axis of a light guide F, carries out incidence to a rod lens 40, and reaches the outgoing radiation side of a rod lens 40 with breadth at the include angle of about 8.6 degrees after that. And it laps with the light which carried out outgoing radiation from the center section of the light guide F in respect of the outgoing radiation of a rod lens 40, and outgoing radiation is carried out from the outgoing radiation side of a rod lens 40 at the include angle near 12.7 degrees to an optical axis. in addition — a rod lens — 40 — inside — an angle of divergence — whenever — theta — ' (about 8.6 degrees) — a rod lens — 40 — the quality of the material — it is — quartz glass — a refractive index — n — ' (= 1.47) — air — a refractive index — n (= 1) — air — inside — an angle of divergence — whenever — theta (12.7 degrees) — from — a Snell's law ( $n \sin \theta = n' \sin \theta'$ ) — being based — it can ask .

[0018] In order to use light most efficiently, as shown in drawing 6 , as for the light which carried out incidence to the rod lens 40, it is desirable to spread into the outgoing radiation flat-tapped cup of a rod lens 40 in the peripheral face of a rod lens 40. Then, since the quality of the material is quartz glass, and whenever [ angle-of-divergence ] is about 8.6 degrees when a path is phi3.5mm, the die length of a rod lens 40 is better than about 12mm or 12mm to make it a short jar a little.

[0019] The light which carried out incidence of the light which carried out outgoing radiation from the outgoing radiation side of a rod lens 40 to the plano-convex lens 50, and carried out outgoing radiation from the plano-convex lens 50 is the radius of curvature R3 of a plano-convex lens 50. It is based, and it is refracted and condenses to the optical exposure side of the set-up location. Here, the distance d from a plano-convex lens 50 to an irradiated plane is equivalent to the focal distance of a plano-convex lens 50. That is, a rod lens 40 and a plano-convex lens 50 commit the projection lens which projects the illumination distribution of the outgoing radiation edge Fou of a light guide F on an irradiated plane. Moreover, the illuminance distribution of the outgoing

radiation edge Fou of a light guide F is equalized by the effectiveness of the random arrangement of an optical fiber. Therefore, by work of a rod lens 40, even if it lengthens distance d from the outgoing radiation section to an irradiated plane, "extract inside" does not arise in the illumination distribution of the exposure field in an irradiated plane.

[0020] Drawing 8 shows the irradiance distribution curve of the above-mentioned example which prepared the projection optics which consists of a rod lens 40 and a plano-convex lens 50 in the outgoing radiation edge Fou of a light guide F, and the conventional example shown in drawing 1 which does not prepare projection optics in the outgoing radiation edge Fou of a light guide F. Although the irradiance distribution curve in case the distance d from a plano-convex lens 50 thru/or the outgoing radiation edge Fou of a light guide F to an irradiated plane is 15mm and 20mm was searched for, the rod lens 40 and the plano-convex lens 50 were designed as the aforementioned distance of  $d = 15\text{mm}$ . Moreover, the diameter of convergence of an optical fiber is  $\phi 3.5\text{mm}$ .

[0021] The phenomenon "extract inside" in any [  $d = 15\text{mm}$  and  $d = 20\text{mm}$  ] case was not accepted for this example so that drawing 8 might show. And since light was condensed by the irradiated plane which is  $d = 15\text{mm}$ , the illuminance of this example of an exposure field center section was much larger than the conventional example, and the sharp distribution curve was acquired. The illuminance of an exposure field center section being not only lower than this example but the phenomenon on the other hand, "be extracted inside" in the conventional example in the case of  $d = 20\text{mm}$  was seen.

[0022] Although drawing 7 shows one example of the optical-path Fig. of invention of claim 2 which does not use a plano-convex lens 50, it is the same as drawing 6 which shows the optical-path Fig. of invention of claim 1 until the light which carried out incidence to the rod lens 40 arrives at an outgoing radiation side. However, radius of curvature R2 of the outgoing radiation side of a rod lens 40 Radius of curvature R1 of plane of incidence Since it is small, light is refracted more greatly than the time of incidence, and outgoing radiation of it is carried out from a rod lens 40, and it condenses to the optical exposure side of the set-up location. That is, since a rod lens 40 commits the projection lens which projects the illumination distribution of the outgoing radiation edge Fou of a light guide F on an irradiated plane, it is and "extract inside" does not produce the same effectiveness as having used the plano-convex lens 50 in the illumination distribution of the exposure field in an irradiated plane. And since a plano-convex lens 50 is not used, components mark can be lessened, and since loss of the light by reflection or absorption decreases, an illuminance becomes high.

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**DESCRIPTION OF DRAWINGS**

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**[Brief Description of the Drawings]**

**[Drawing 1]** It is the explanatory view of a light irradiation device.

**[Drawing 2]** It is the explanatory view of "extract inside" of illumination distribution.

**[Drawing 3]** It is the explanatory view of the conventional example of the optical outgoing radiation section.

**[Drawing 4]** It is the sectional view of the optical outgoing radiation section of invention of claim 1.

**[Drawing 5]** It is the sectional view of the optical outgoing radiation section of invention of claim 2.

**[Drawing 6]** It is the optical-path Fig. of invention of claim 1.

**[Drawing 7]** It is the optical-path Fig. of invention of claim 2.

**[Drawing 8]** It is an irradiance distribution curve Fig.

**[Description of Notations]**

10 Discharge Lamp

11 Cathode

12 Anode Plate

20 Mirror

30 Attachment Component

40 Rod Lens

50 Plano-convex Lens

F Light guide

Fin Incidence edge of a light guide

Fou Outgoing radiation edge of a light guide

FJ Joint

H Electrode holder

St Shutter

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**[Translation done.]**

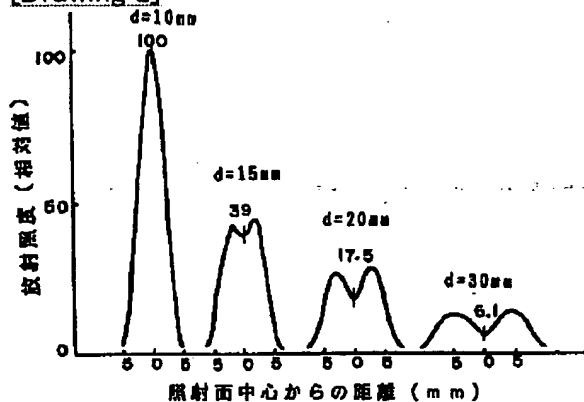
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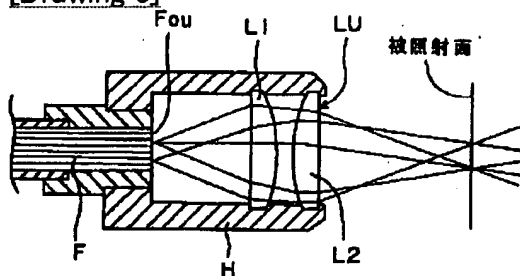
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DRAWINGS

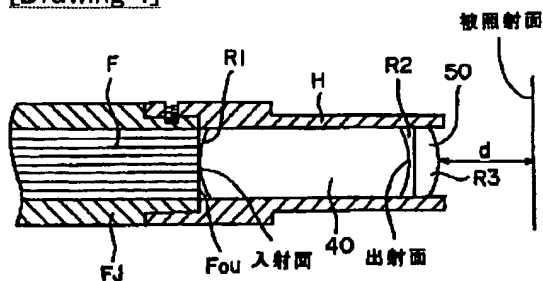
[Drawing 2]



[Drawing 3]

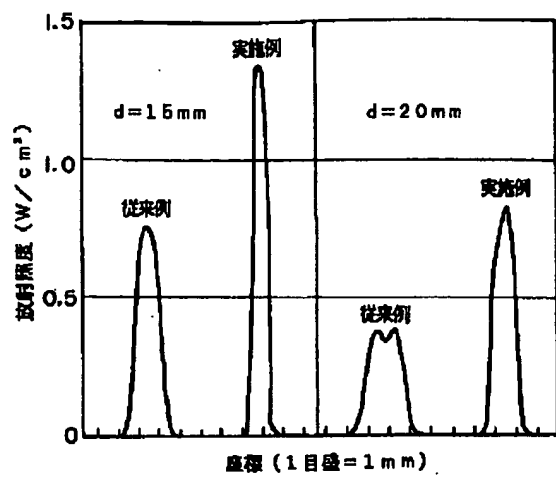


[Drawing 4]



[Drawing 1]





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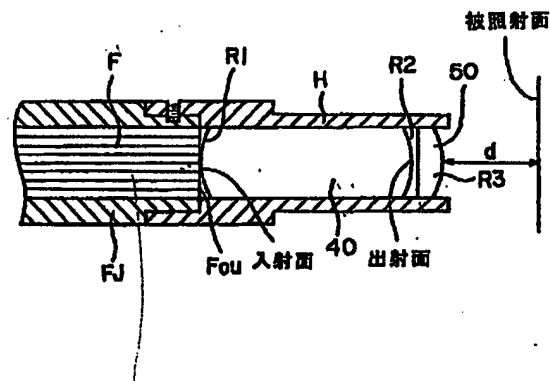
9A001 KK15 KK16

(54) 【発明の名称】 光照射装置

(57) 【要約】

【課題】 光出射部の径が大型化することがなく、光出射部をワークに接近させて高い放射照度で光照射することが可能であり、また、光出射部とワークとが離れていても、被照射面に照射される光の「中抜け」がなく、効率よく光照射することが可能な光照射装置を提供する。

【解決手段】 放電ランプの光をライトガイドFの入射端に入射し、ライトガイドの出射端から出射する光を投影光学系により被照射面に集光し、被照射面に配置されたワークに照射する光照射装置において、投影光学系を、両端に曲率半径が同じ球面を有するロッドレンズ40と平凸50または両凸レンズとで構成する。また、この投影光学系を、両端が球面のロッドレンズで構成し、ロッドレンズの出射端の球面の曲率半径を入射端の球面の曲率半径よりも小さくする。



## 【特許請求の範囲】

【請求項1】 放電ランプから放射された光をミラーで集光し、集光した光を、ミラーの光軸上に配置したライトガイドの入射端に入射し、ライトガイドの出射端から出射する上記光を投影光学系により被照射面に集光し、被照射面に配置された被照射物に照射する光照射装置において、

前記投影光学系は、両端に曲率半径が同じ球面を有し、入射端が該ライトガイドの出射端に近接して配置されたロッドレンズと、該ロッドレンズの出射端に近接して配置された平凸または両凸レンズからなることを特徴とする光照射装置。

【請求項2】 放電ランプから放射された光をミラーで集光し、集光した光を、ミラーの光軸上に配置したライトガイドの入射端に入射し、ライトガイドの出射端から出射する上記光を投影光学系により被照射面に集光し、被照射面に配置された被照射物に照射する光照射装置において、

前記投影光学系は、入射端が該ライトガイドの出射端に近接して配置された、両端が球面のロッドレンズからなり、該ロッドレンズの出射端の球面の曲率半径が入射端の球面の曲率半径よりも小さいことを特徴とする光照射装置。

【請求項3】 紫外線硬化接着剤が塗布された前記被照射物に前記光を照射することを特徴とする請求項1又は請求項2記載の光照射装置。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は、放電ランプから放射される光をライトガイドで導いて被照射面に配置された被照射物（ワーク）に照射して光処理を行う光照射装置に関し、更には狭い範囲の領域に紫外線を含む光を照射して紫外線処理を行うのに適した光照射装置に関するものである。

## 【0002】

【従来の技術】光照射装置から出射される光をワークに塗布した接着剤、塗料、インキ、レジストなどに照射して硬化させたり乾燥させることが行われる。また、逆に、これらを溶融させたり軟化させるなどのさまざまな処理が行われる。そして、紫外線硬化型接着剤による光ディスク用のピックアップレンズの接着や、電子部品の基板への接着の場合などは、微小域に光を照射する必要がある。放電ランプの光を光ファイバーを多数束ねて構成されるライトガイドで導いて微小域に照射する。

【0003】図1は、微小域に照射するための光照射装置の内部構成の一例を示す。ミラー20が保持部材30に固定され、放電ランプ10もミラー20の貫通孔21に挿通された状態で保持部材30に固定されている。放電ランプ10は、例えばキセノンランプや超高圧水銀ランプなどのショートアーク型の放電ランプであり、発光

管内に陰極11と陽極12が対向配置されている。ミラー20は、断面形状が楕円形であり、放電ランプ10の陰極11と陽極12の間の発光部の輝点がミラー20の第1焦点に位置している。通常、発光部の輝点は陰極先端付近にある。ミラー20の光軸L上にライトガイドFが配置され、ライトガイドFの入射端Finがミラー20の第2焦点に位置している。また、ライトガイドFの入射端Finと放電ランプ10の間にはシャッターStが配置されており、シャッターStを開くと、ミラー20で集光された光はライトガイドFの入射端Finに入射する。そして、ライトガイドFの出射端Fouから出射した光は被照射面における光照射領域に配置された光照射処理を行うワーク、例えば紫外線硬化型接着剤が塗布されたレンズ部品や基板などに照射される。

【0004】かかる光照射装置において、上記したようにミラー20の中央部分には貫通孔21が形成されているので、この部分には反射光が存在せず、ミラー20で反射する光は、図1において点線斜線で示した光のみがライトガイドFの入射端Finに入射する。つまり、入射端Finには、入射角度の大きな光が多く入射し、入射角度の小さな0°に近い光はほとんど入射しない。

【0005】ライトガイドFの入射端Finに入射した光は、光ファイバーの性質として角度が保持された状態で反射を繰り返してライトガイドF内を伝送し、入射角と同じ角度で出射端Fouから出射する。上記したようにライトガイドFには、入射角度の大きな光が多く入射するので、出射端Fouから出射する光は、図1において点線斜線で示した出射角度の大きな光が多く出射する。ここで、ライトガイドFの出射端Fouとワークが配置される被照射面との距離dが短いと、被照射面の照度分布は、出射角度の小さな0°に近い光が少なくても、ライトガイドFの光ファイバの収束径がある程度、例えばφ5mmやφ3.5mmという大きさを有するため、中央の照度が高く、周辺部ほど低い山形になる。

【0006】しかし、ライトガイドFの出射端Fouと被照射面との距離dが大きくなると、被照射面における照射領域の照度は周辺部に比べて中央部が低くなり、

「中抜け」と称する現象が生じる。図2は、光ファイバの収束径がφ3.5mmの場合に、ライトガイドFの出射端Fouと被照射面との距離dと「中抜け」の関係を示すが、距離dが20mm以上になると「中抜け」現象が顕著になる。そして、ワークの大きさや形状、ワークの搬入、搬出機構とのクリアランスの関係などから、ライトガイドFの出射端Fouとワークが配置される被照射面との距離dを20mm以上にする場合が多い。

【0007】光処理時間を短くするためには、高い照度で処理する必要がある。しかし、出射端Fouとワークが配置される被照射面との距離が長い場合に、光ディスク用のピックアップレンズなどの小さなワークを照射領域の中央に配置すると、「中抜け」現象のためにワーク



に照射される光の照度が低くなり、処理時間が長くなる。このため、ワークを照射領域の中央からずらして、照度が高い照射領域の周辺部に配置して照射している。しかし、異なる種類のワークを光処理するときや、ライトガイドFの出射端Fouとワークが配置される被照射面との距離dが変更されると、その都度被照射面の照度分布を測定して、照度が最も高くなる場所を求め、ワークがその位置に来るように適宜設定する必要がある。また、照度の高い領域は照射領域の周辺部であり、その範囲は狭いので、精度良くワーク位置を合わせ込む必要があり、段取り変えに手間と時間を要していた。

【0008】

【発明が解決しようとする課題】この「中抜け」現象を解消するために、ライトガイドの出射端から出射する光を投影光学系にて被照射面に集光して、被照射面に配置されたワークに照射することが考えられる。この場合、ライトガイドの出射端の照度分布を投影光学系にて被照射面に投影するので、被照射面において照射を必要とする領域に対して、効率よく光を照射できるとともに、照度分布の「中抜け」現象を解消することができる。

【0009】特開昭64-75067号公報には、上記投影光学系として複数のレンズを組み合わせたレンズユニットを使用することが開示されている。図3は、第1レンズL1と第2レンズL2からなるレンズユニットLUの一例を示し、ライトガイド出射端にレンズユニットLUが取り付けられ、光照射部が構成されている。図3において、ライトガイドFの出射端Fouから出射した光は、ライトガイドFを形成する光ファイバーの開口数NAに従って一定の広がりを持つ。例えば石英ガラス製の光ファイバーの場合、開口数NA=約0.22であり、その空気中の広がり角は約12.7°に相当する。

【0010】ここで、レンズユニットLUのレンズL1、L2をライトガイドFの出射端Fouに近づけると、レンズユニットLUによって被照射面に投影される倍率が大きくなる。つまり被照射面における投影面積が大きくなるので、照射領域全体の照度は低くなる。従って、狭い領域に高い照度で照射するためには、レンズユニットLUのレンズL1、L2をライトガイドFの出射端Fouから所定距離だけ離す必要がある。そして、ライトガイドFの出射端Fouから出射した光を有効に利用するために、前記した約12.7°の広がり角で広がった光のほとんどをレンズにより集光しなければならないが、そのためには、図3に示すように、レンズユニットLUのレンズ径を大きくする必要がある。このため、レンズを保持するホルダHを含むレンズユニット径がライトガイドFの径よりもかなり大きくなり、光出射部の形状が大型化する。なお、レンズと被照射面との距離を長くする場合にも、ライトガイドFの出射端Fouからレンズまでの距離を長くする必要があるので、上記したように、レンズ系は大きくなり、光出射部の形状は大型

化する。

【0011】実際の光照射処理においては、ワークを固定するための治具がその周りを囲っていたり、光を照射する部分が基板に実装された他の部品に囲まれた中に位置する場合などがあるが、いずれにしても、光出射部の形状が大型であれば、光出射部をワークの光を照射する部分に十分に接近させて照射することができず、所望の放射照度を得られない不具合がある。

【0012】そこで本発明は、光出射部の径が大型化することがなく、光出射部をワークに接近させて高い放射照度で光照射することが可能であり、また、光出射部とワークとが離れていても、被照射面に照射される光の「中抜け」がなく、効率よく光照射することが可能な光照射装置を提供することを目的とする。

【0013】

【課題を解決するための手段】かかる目的を達成するために、請求項1の発明は、放電ランプから放射された光をミラーで集光し、集光した光を、ミラーの光軸上に配置したライトガイドの入射端に入射し、ライトガイドの出射端から出射する光を投影光学系により被照射面に集光し、被照射面に配置されたワークに照射する光照射装置において、投影光学系を、両端に曲率半径が同じ球面を有し、入射端がライトガイドの出射端に近接して配置されたロッドレンズと、このロッドレンズの出射端に近接して配置された平凸または両凸レンズとで構成する。また、請求項2の発明は、この投影光学系を、入射端がライトガイドの出射端に近接して配置された、両端が球面のロッドレンズで構成し、ロッドレンズの出射端の球面の曲率半径を入射端の球面の曲率半径よりも小さくする。更には請求項3の発明は、紫外線硬化型接着剤を硬化するために、上記のように構成した投影光学系を備えた光照射装置を用いる。

【0014】

【発明の実施の形態】以下に、図面に基いて本発明の実施の形態を具体的に説明する。図4は、請求項1の発明の光出射部の実施例の断面図である。つまり、本発明の光照射装置の光源部分は図1に示すとおりであり、図1のライトガイドFの先端部が図4に示す構造になっている。図4において、ライトガイドFは、石英ガラスからなる多数の光ファイバーを、個々の光ファイバーの入射端Finにおける位置と出射端Fouにおける位置がランダムになるように配列して束ねたものである。このライトガイドFの出射端Fouの側面は筒状の金物である接合部FJで覆われており、接合部FJに筒状のホルダーHが接合されている。そして、ホルダーH内には、投影光学系として働く石英ガラス製のロッドレンズ40および平凸レンズ50が保持されている。ここで、ロッドレンズ40および平凸レンズ50の外径は光ファイバーの収束径にほぼ等しいか、少し大きめである。光ファイバーの収束径の具体例は、例えばφ3.5mmであ

り、接合部F Jの外径はφ9mmである。ロッドレンズ40および平凸レンズ50の外径は、φ3.5mmと同じか、幾分大きい程度である。従って、ホルダーHの外径を接合部F Jの外径よりも大きくすることなく、投影光学系を設けることができるので、光出射部の外径は拡大しない。

【0015】ロッドレンズ40の両端は球面であり、一方の端はライトガイドFからの光を入射する入射面、もう一方の端は入射した光を出射する出射面である。ロッドレンズ40の入射面をライトガイドFの出射端F o u 10 に近接して設ける。つまり、ロッドレンズ40の入射面はライトガイドFの出射端F o uに接触するか、もしくは1mm以内の短い間隔で保持されている。ロッドレンズ40の入射面の曲率半径R1と出射面の曲率半径R2とは等しくなっている。また、ロッドレンズ40の出射面側に設けられた平凸レンズ50の曲率半径はR3であり、この曲率半径R3、およびロッドレンズ40の曲率半径R1(=R2)とロッドレンズ40の光軸方向の長さは、平凸レンズ50を出射した光を集光させる被照射面までの距離dに応じて設計される。なお、平凸レンズ50は両凸レンズであってもよい。

【0016】図5は請求項2の発明の光出射部の実施例を示すが、ホルダーH内には、外径が光ファイバーの収束径にほぼ等しいか、少し大きめのロッドレンズ40のみが保持されている。ロッドレンズ40の両端は上記第1の実施例の場合と同様に球面であるが、出射面の曲率半径R2を入射面の曲率半径R1よりも小さくすることにより、ロッドレンズ40の出射側に凸レンズを設けることを不要とすることができる。そして、曲率半径R1およびR2とロッドレンズ40の光軸方向の長さは、ロッドレンズ40を出射した光を集光させる被照射面までの距離dに応じて設計される。

【0017】しかし、図1に示す放電ランプ10を点灯し、シャッターS tを開くと、ミラー20で集光された光はライトガイドFの入射端F i nに入射し、ライトガイドFの出射端F o uから出射するが、請求項1の発明の場合は、図6に示すように、ライトガイドFの出射端F o uのほぼ中央部の光ファイバーから出射した光は、最大出射角度を12.7°(ファイバーのNAの約0.22に相当)とすると、ロッドレンズ40の入射面で屈折し、約8.6°の角度で広がりながらロッドレンズ40の出射面に達する。そして、ロッドレンズ40の出射面から光軸にほぼ平行な光として出射する。一方、ライトガイドFの出射端F o uの周辺部の光ファイバーから出射した光は、ロッドレンズ40の入射面が球面形状であるので、ライトガイドFの光軸方向に屈折してロッドレンズ40に入射し、その後は、約8.6°の角度で広がりながら、ロッドレンズ40の出射面に達する。そして、ロッドレンズ40の出射面でライトガイドFの中央部から出射した光と重なり、光軸に対して12.7

に近い角度でロッドレンズ40の出射面から出射する。なお、ロッドレンズ40中での広がり角度 $\theta'$ (約8.6°)は、ロッドレンズ40の材質である石英ガラスの屈折率 $n'$ (=1.47)、空気の屈折率 $n$ (=1)、空気中での広がり角度 $\theta$ (12.7°)から、スネルの法則( $n \sin \theta = n' \sin \theta'$ )に基づいて求めることができる。

【0018】光を最も効率よく利用するためには、ロッドレンズ40に入射した光は、図6に示すように、ロッドレンズ40の外周面に当たることなく、ロッドレンズ40の出射面一杯に広がるのが望ましい。そこで、ロッドレンズ40の長さは、材質が石英ガラスであり、径がφ3.5mmの場合、広がり角度が約8.6°であるので、約12mmまたは12mmよりやや短かめにするのがよい。

【0019】ロッドレンズ40の出射面から出射した光は、平凸レンズ50に入射し、平凸レンズ50から出射した光は、平凸レンズ50の曲率半径R3に基づいて屈折し、設定された位置の光照射面に集光する。ここで、平凸レンズ50から被照射面までの距離dは平凸レンズ50の焦点距離に相当する。すなわち、ロッドレンズ40と平凸レンズ50が、ライトガイドFの出射端F o uの照度分布を被照射面に投影する投影レンズの働きをする。また、ライトガイドFの出射端F o uの照度分布は、光ファイバーのランダム配列の効果により均一化されている。従って、ロッドレンズ40の働きにより、出射部から被照射面までの距離dを長くしても被照射面における照射領域の照度分布に「中抜け」が生じない。

【0020】図8は、ライトガイドFの出射端F o uにロッドレンズ40および平凸レンズ50からなる投影光学系を設けた前述の実施例、およびライトガイドFの出射端F o uに投影光学系を設けない図1に示す従来例の放射照度分布曲線を示す。平凸レンズ50ないしライトガイドFの出射端F o uから被照射面までの距離dが15mmおよび20mmの場合の放射照度分布曲線を求めたが、ロッドレンズ40および平凸レンズ50は、前記の距離d=15mmとして設計した。また、光ファイバーの収束径はφ3.5mmである。

【0021】図8から分かるように、本実施例は、d=15mmおよびd=20mmのいずれの場合も「中抜け」現象は認められなかった。そして、本実施例は、光がd=15mmの被照射面に集光されるので、照射領域中央部の照度が従来例よりもずっと大きく、シャープな分布曲線が得られた。一方、従来例では、照射領域中央部の照度が本実施例より低いばかりでなく、d=20mmの場合に「中抜け」現象が見られた。

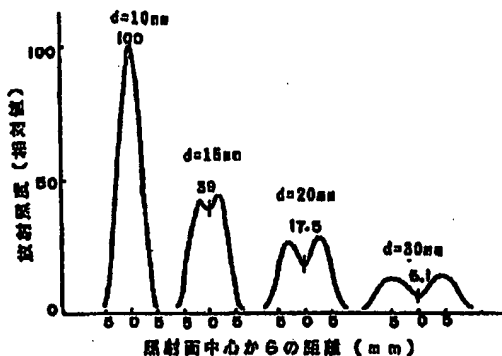
【0022】図7は、平凸レンズ50を使用しない請求項2の発明の光路図の1例を示すが、ロッドレンズ40に入射した光が出射面に到達するまでは、請求項1の発明の光路図を示す図6と同じである。しかし、ロッドレ

レンズ40の出射面の曲率半径 $R_2$ が入射面の曲率半径 $R_1$ よりも小さいので、光は入射時より大きく屈折してロッドレンズ40から出射し、設定された位置の照射面に集光する。すなわち、ロッドレンズ40が、ライトガイドFの出射端Fouの照度分布を被照射面に投影する投影レンズの働きをするので、平凸レンズ50を使用したのと同じ効果があり、被照射面における照射領域の照度分布に「中抜け」が生じない。そして、平凸レンズ50を使用しないので、部品点数を少なくでき、反射や吸収による光の損失が減るので照度が高くなる。

#### 【0023】

【発明の効果】以上説明したように、本発明は、ライトガイドから出射する光を、ロッドレンズ、またはロッドレンズと平凸または両凸レンズからなる投影光学系により被照射面に集光するので、被照射面までの距離が大きい場合にも、照度分布に「中抜け」現象が発生せず、照射領域中央部の放射照度を高くすることができる。また、従来、ライトガイドとレンズとの間、レンズとレンズとの間の空気層の占める割合が多く、その分レンズ径が大きくなっていたが、該空気層を屈折率の大きいロッドレンズと置き換えることにより、ロッドレンズおよび平凸または両凸レンズの径をライトガイドの径とほぼ同等にすることができる。従って、ライトガイドの出射端に投影光学系を設けたにもかかわらず光出射部の径は拡大しない。このため、被照射物であるワークとその搬入機構などとのクリアランスが小さい場合にも、光出射部をワークに接近させることが可能になる。また、出射部からワークまでの距離が大きくなっても「中抜け」のな\*

【図2】



\*い光を照射することができる。従って、出射端から被照射面までの距離の長短にかかわらず、照射条件の調整を容易に行うことができ、ワークの材質や種類が変化しても、その照射条件に対して自在に対応できる。

#### 【図面の簡単な説明】

【図1】 照射装置の説明図である。

【図2】 照度分布の「中抜け」の説明図である。

【図3】 光出射部の従来例の説明図である。

【図4】 請求項1の発明の光出射部の断面図である。

10 【図5】 請求項2の発明の光出射部の断面図である。

【図6】 請求項1の発明の光路図である。

【図7】 請求項2の発明の光路図である。

【図8】 放射照度分布曲線図である。

#### 【符号の説明】

10 放電ランプ

11 陰極

12 陽極

20 ミラー

30 保持部材

20 40 ロッドレンズ

50 平凸レンズ

F ライトガイド

Fin ライトガイドの入射端

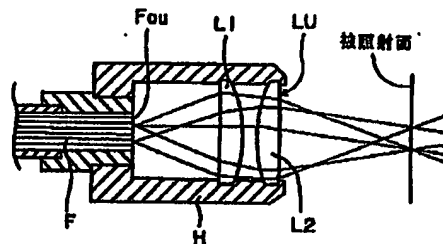
Fou ライトガイドの出射端

FJ 接合部

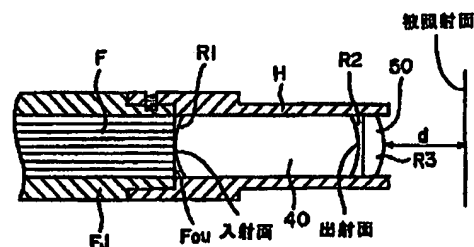
Hホルダー

St シャッター

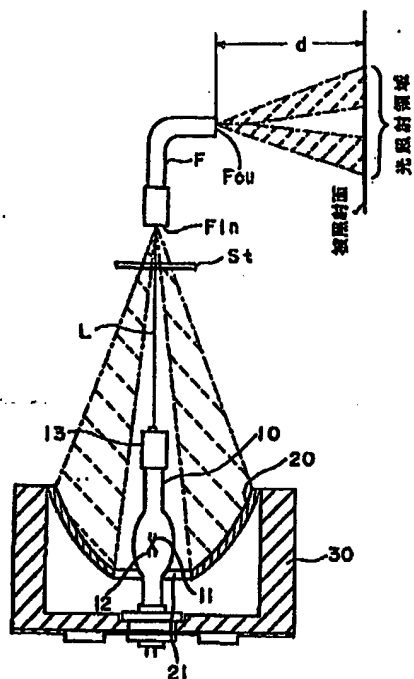
【図3】



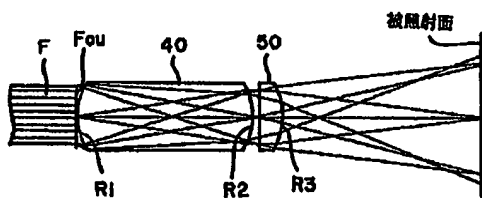
【図4】



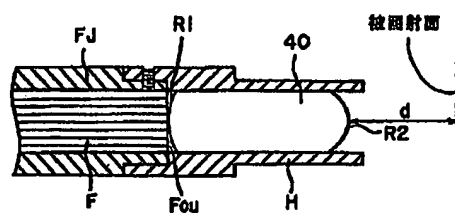
【図1】



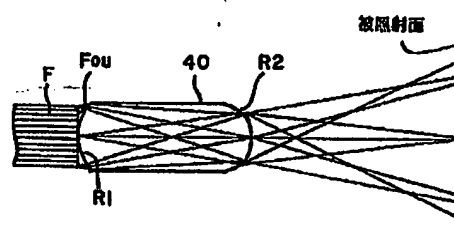
【図6】



【図5】



【図7】



【図8】

